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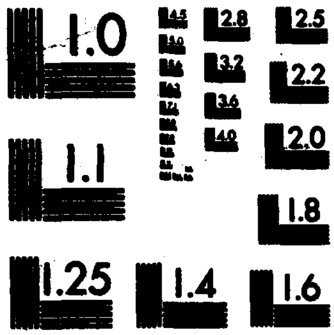

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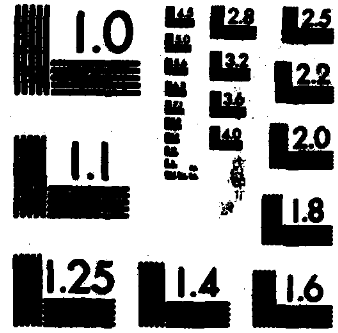

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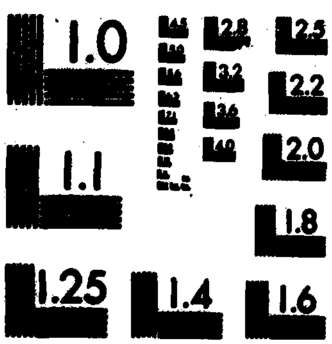

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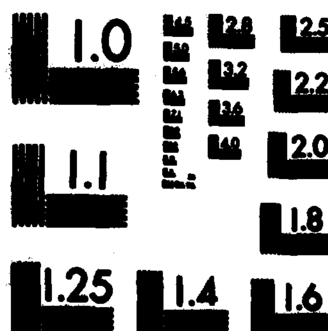

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FINAL REPORT

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Author: ERIC REISSNER

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Summary of research results on formulation of theories of elastic shells, plates and beams. Results for unconventional beam buckling problems. Results for stress concentrations in shells due to holes or rigid inserts. Deflection bounds for unconventional beam problems.

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DESCRIPTION OF EFFORT

Contract N00014-75-C-0158

The theme of this contractual effort has been the establishment of research results concerning stresses and deformations in "thin" elastic bodies.

The prototype of a thin body is that of a "shell", such as a spherical shell (sometimes designated as dome), or cylindrical shell (straight tube), or toroidal shell (curved tube). The special case of a shell without curvature in its natural state is usually designated as "plate", still other thin bodies are "beams", for which instead of the adjective "thin" one sometimes uses the adjective "slender."

One of the fundamental problems of shell theory is the formulation of two-dimensional theories (or, for beams, of one-dimensional theories) by "direct methods," or as a consequence of a given three-dimensional, linear or non-linear statement of the laws of continuum mechanics. The nature of the step from three dimensions to two or one dimensions may be described briefly by saying that it may depend either on formal asymptotic expansion procedures or on variational procedures having the character of a generalized least-squares approach.

Examples of the direct approach to the solutions . problem are to be found in items 27, 29 and 34 in the appended list of Technical Reports. Examples of the use of asymptotic expansion procedures are given by items 7 and 12. Examples of the use of the generalized least-squares procedure are items 4, 8, 9, 18 and 28 in the appended list.

In addition to the problem of formulating two-dimensional shell theories and one-dimensional beam theories, some of the work done under the terms of the contract has been concerned with solutions or solution procedures for specific problem of technical interest which can be stated within the framework of established two and one dimensional theories. Among these the following are mentioned specifically.

Novel asymptotic results for two-dimensional sixth order theories of shear deformable plates were presented in three reports (5, 23, 31).

Contributions to the understanding of the distribution of stress and strain in laminated anisotropic (composite materials) cylindrical shells were made in report number 6.

Results concerning finite deflections of circular ring plates and toroidal tubes may be found in reports number 11 and 29.

Several investigations have been concerned with non-conventional problems of axial and lateral beam buckling, including the effects of follower forces, shear deformability, and non-coincident centroidal and shear center locations (2, 16, 24, 32).

Altogether five reports have been devoted to the problem of stress concentrations in shallow spherical shells in states of uniform membrane shear or transverse twisting, due to the effect of a small circular hole or rigid inclusion. These problems were recognized, serendipitously, to represent explicitly solvable problems of shell theory (with previously known classical solutions for the special case of flat plates). They were furthermore found to be particularly suitable examples to illustrate the use of an asymptotic expansion procedure for unsymmetrical shell problems which the Principal Investigator had obtained in 1956. Among

the significant consequences of the analysis of these stress concentration problems was the discovery of the existence of shell problems for which the asymptotic "interior" solution contribution displays physically distinct "near-field" and "far-field" behavior, shifting from "membrane" properties to "inextensional bending" properties, in a manner which depends on the nature of the interaction between "interior" and "edge zone" solution contributions (19, 20, 21, 30).

Contributions to an understanding of the concept of a warping boundary layer in one-dimensional beam theory and the relation of this concept to the problem of determining shear center locations in prismatical beams were made in reports number 15, 17 and 22.

Finally, several reports have dealt with the possibility of determining "upper and lower bounds" for influence coefficients in the theory of orthotropic or anisotropic laminated beams, either based on the theory of plane stress or on the theory of torsion of shafts of varying circular cross section (1, 3, 10, 13, 14).

TECHNICAL REPORTS

Contract N0014-75-C-0158

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   J. Engg. Mech. Div. (ASCE) 102, EM3, pp. 559-563, 1976

5. On the Theory of Transverse Bending of Elastic Plates
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9. On Small Bending and Stretching of Sandwich-Type Shells
   Int. J. Solids Structures 13, pp. 1293-1300, 1977

10. On Bounds for the Torsional Stiffness of Shafts of Varying Circular Cross Section
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11. A Note on Finite Deflections of Circular Ring Plates
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12. Two and Three-Dimensional Results for Rotationally Symmetric Deformations of Circular Cylindrical Shells
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22. On Torsion and Transverse Flexure of Orthotropic Elastic Plates
J. Appl. Mech. 47, pp. 855-860, 1980

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